ISBN 0-662-22414-0 Cat. No. Fo 29-6/7-1994E

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FOREST Pest LEAFLET

Tomentosus root disease

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Introduction

Tomentosus root disease is caused by the fungus *Inonotus tomentosus*, which is one of the most widespread root-rotting fungi in boreal and subboreal forests. It occurs throughout the temperate zone of the northern hemisphere. The root rot was first described in Canada in 1922, but due to its insidious habits, the extent and importance of the disease was largely overlooked until the 1960s. Unfortunately, *I. circinatus*, the causal agent of a root disease with identical symptoms, has not been recognized as distinct for many years, and the disease it causes is often thought to be caused by *I. tomentosus*. This has resulted in confusion about the hosts, distribution, and biology of tomentosus root disease. Only in the mid-1980s did the distribution and impact of this disease in British Columbia's forests become a major concern.

Blowdown of infected spruce

Hosts and distribution

In British Columbia, tomentosus root disease is the major root disease in interior spruce (*Picea* spp.) stands. It is reported to attack many other conifer species. However, the host range is uncertain as *I. tomentosus* is easy to mis-identify. The decay pattern is similar to that caused by *Phellinus pini*, *I. circinatus*, and perhaps unrecognized *Inonotus* species. Species identification based on cultures from wood samples is sometimes uncertain as some strains of these fungi are indistinguishable. Sporophores, although now considered distinct by experts, have been mis-assigned in the past. Additionally, *I. tomentosus* fruits on the ground, in association with host roots, but tracing the root to identify the host may not have been done throughly. In some years, *I. tomentosus* fruits prolifically in our northern forests where spruce is the dominant species, and in high-elevation stands in southern British Columbia. In some parts of British Columbia, lodgepole pine is considered to be a major host, but the extent of the disease on this host is unknown.

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Fruiting bodies (sporophores) are tan to yellow-brown on the upper surface (left), and cream to yellow-brown on the underside (right).

Life history

Infection on spruce usually occurs when there is root contact between healthy and infected root systems, particularly of roots less than 2 cm in diameter. The fungal mycelium may grow along the healthy root bark before killing the bark and gaining access to the xylem. Once the disease is established in the woody tissue of the root, it typically advances up the center of the root toward the bole at a rate of approximately 3-4 cm/year, eventually moving into other uninfected major roots. Typically, decay will progress up the main bole for 1 m above the ground. In living trees, stained wood will often precede advanced decay by 1 m. Inoculated samples developed a pink stain within 12 months, and white-pocket advanced decay within 18 months. The sapwood of large roots frequently will remain uninfected and maintain its primary functions even when advanced rot occupies up to 80% of the root wood. These factors allow large, infected trees to maintain a relatively healthy crown long after they are attacked by the fungus.

In lodgepole pine, the pink stain is less pronounced and infection may be associated with resin-soaked wood, which inhibits advanced decay but does not impede progress of the fungus. Extended butt rot occurs less frequently than in spruce, while crown thinning and mortality are more common than in spruce.

After an infected tree dies or is cut, the fungus spreads radially only; however, infected stumps may contain viable mycelium for up to 30 years. Roots of healthy trees must grow into contact with this infected tissue before the fungus can spread from old stumps.

Sporophores are centrally stipitate (stemmed) and directly or indirectly associated with infected tree roots. They range from 2 to 11 cm in diameter and are not more than 1.5 cm thick. The upper surface is usually tan to yellow-brown with a velvety to hairy texture, usually centrally depressed, and sometimes faintly concentric. The cream to yellow-brown underside has pores which continue part way down the stipe (stem). They are produced after cool summer or fall rains, and are consumed by invertebrates or decayed, so they may be overlooked in the forest. Optimum conditions for spore release occur when light intensity is

low, when relative humidity is high, and when the temperature is between 16 and 22°C. Under controlled conditions, spore-induced infection has been induced on wounded roots and germinated spores are common near fruiting bodies. Root disease centers are small, and of different genotypes, and different genotypes can be found within large centers. This indicates that spores are important for initiating new disease centers.

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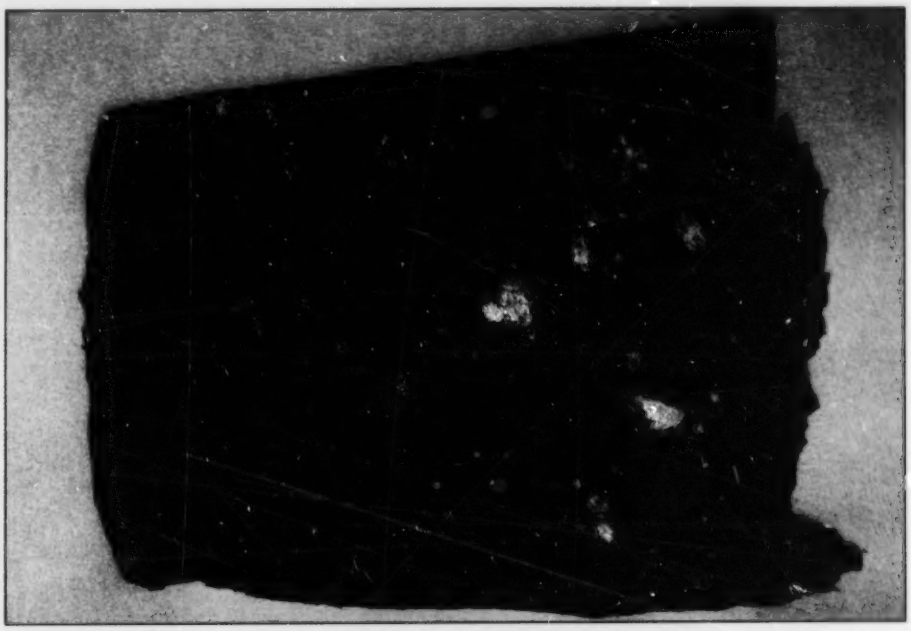
Reduced leader growth and distress cone crop in young infected spruce

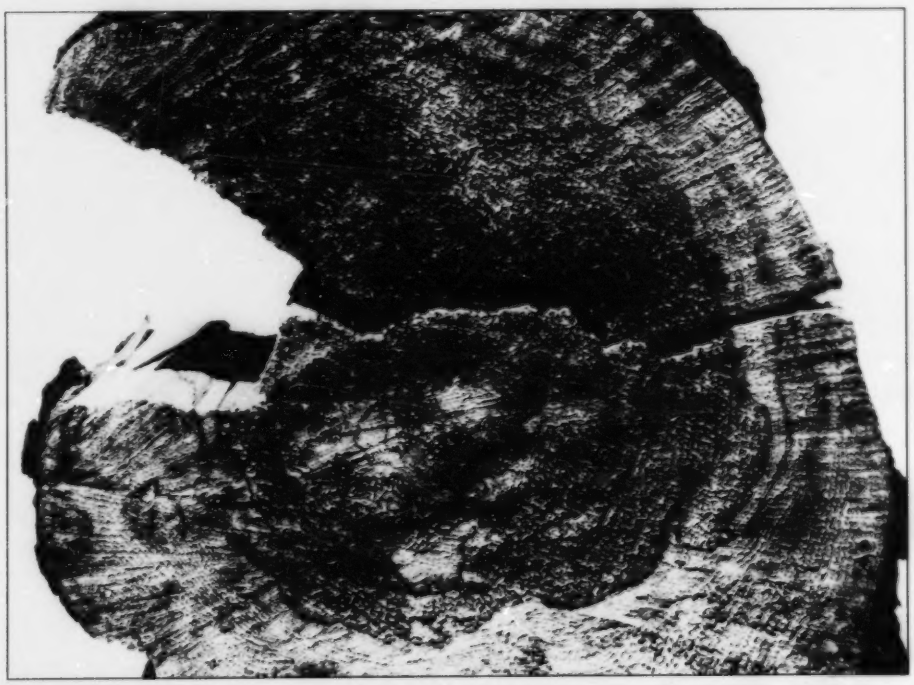
Identification

Spruce old growth

Tree crowns seldom show typical symptoms until the root rot is well advanced; these symptoms include reduced height growth, stunted upper branches, and thin crowns. However, these symptoms are not unique to tomentosus root rot, and they can be caused by other problems. As the disease center expands radially, there will be windthrown trees or standing dead trees in the disease center, often attacked by spruce beetle, *Dendroctonus rufipennis* (see Forest Pest Leaflet No. 13). Sporophores are produced sporadically, and are short-lived, but if observed they may aid in delineating the extent of the infested area. Since both healthy-appearing and symptomatic trees may or may not have root disease, roots must be sampled to properly assess the extent of a root disease problem. Recently killed trees are particularly good to sample for decay symptoms. Often in these trees the decay is extensive, so several roots at the root collar will show the advanced white-pitted decay with a leading edge of pink to reddish-brown stain. On living trees the decay is frequently not as advanced and several roots may need to be sampled. Again, this decay pattern alone is not diagnostic; however, if it is found with regularity within a stand, the cause is likely *I. tomentosus*, as the fungi that produce similar symptoms are not believed to be as common in the butts and roots of spruce. Once the stand is felled, stump tops may be examined for the honeycombed decay pattern on their surface. Both *I. circinatus* and *Phellinus pini* can produce a similar surface decay pattern and similar white pits are observed in longitudinal sections



White-pitted rot of advanced decay with margin of incipient decay of a pale reddish brown or pink color



cross-section of stump showing characteristic honeycombed decay pattern

Thinning foliage on an infected spruce

of butts and roots. If typical *I. tomentosus* sporophores were not observed on the ground before felling, or if the root disease problem is not extensive, then the diagnosis of *I. tomentosus* may be more difficult.

Spruce young growth

In recently planted young trees (1-4 years of age), the first symptom of tomentosus root disease may be death of the tree; these dead trees have white mycelium under the bark which has advanced up a root to the root collar without producing any white-pitted decay in the wood. Very young dead trees are usually very close to old-growth stumps with a typical honeycombed surface decay pattern, and even older dead trees are usually within 2 m of symptomatic old stumps. Starting at about age 5, trees may show chlorosis and a distress crop of cones. Once trees are old enough to produce roots 5-10 cm in diameter, the fungus is more likely to advance to the root collar within the root, as it does in old growth. These trees may show incremental growth reduction. As a stand ages, the surface decay pattern is harder to discern on the old stumps, and there is increasing likelihood that new infections are being initiated by spores.

Other species

Ground-borne stipitate (stemmed) *I. tomentosus* sporophores with associated white-pitted decay, bordered by pink stain, are the most reliable indicators of tomentosus root disease in the field. A similar decay associated with bracket-like fungi on stumps is likely caused by *I. circinatus* or *P. pini*. White-pitted decay bordered by pink stain or a leading edge of pink stain which is commonly found in the roots, even without associated sporophores, is likely caused by *I. tomentosus*, but samples bearing the incipent pink stain should be cultured for a more complete diagnosis.

Push-falling with excavator to remove stumps, which are the source of inoculum

Damage

Tomentosus root disease affects stands directly by decay, growth reduction, predisposition to beetle attack, wind-throw, and mortality. In addition, since inoculum residues accumulate with each cut, this disease has an increasing impact on succeeding generations.

The amount of growth reduction and mortality varies with the amount and distribution of inoculum in the stand, as well as stand age. As a young tree's root system grows, the probability of contact with diseased roots increases; for example, 3% accumulated mortality occurred in eight 20-year-old stands surveyed in the Prince Rupert Region. The most vigorous growing young trees (which have the largest root systems) and trees growing close to old infected stumps tend to be the first to be killed. In several 40 to 60 year old stands, 2 to 3% annual mortality has been documented. In infected mature spruce and lodgepole pine stands, tree mortality will commonly average 30 to 40%. As trees increase in size, the time from initial infection to tree mortality increases. In mature stands, infected trees will frequently be windthrown well before crown symptoms are evident or mortality occurs. Recently dead trees, or those with any above-ground symptoms, will seldom represent more than one-third of the trees with advanced root decay. The rotted root structure, combined with the wind resistance provided by a full crown, will frequently lead to blowdown of the dominant and co-dominant trees in a stand. Endemic levels of spruce beetles breed in these windthrown trees or standing trees having advanced decay.

Merchantable volume is reduced by cull, due to butt rot which may extend up to 5 m above the ground. Losses of spruce saw timber can be extensive as the larger butt logs need to be long-butted to avoid the decay. Most of the severely infected spruce trees have some butt rot, but it generally occurs in less than half of the mature infected lodgepole pine.

Radial increment is substantially reduced by the time root rot is evident in the larger roots. In infected 60-year-old spruce stands, average 5-year basal area increment is about 20% below that of healthy trees. It is not uncommon for growth to be reduced 15 years before a tree is killed. In 40 to 60 year old lodgepole pine stands, annual radial increment of infected trees may be half that of healthy trees.

Many root rot diseases persist and spread once established, thereby endangering succeeding generations. With infected individual root systems of mature spruce trees occupying an area up to 10 m in diameter, the area within a stand that contains inoculum is much larger than in a stand of lodgepole pine. Although inoculum remains viable in roots as small as 2.5 cm in diameter for over 20 years when attached to the stumps, it is unlikely that it will survive that long in detached roots. Most of the viable inoculum causing infection to the new crop resides in the large mass of the stump and major roots. Trees growing within about 2 m of a diseased spruce

or pine stump have a 25% and 10% chance of being infected, respectively. This drops off to about 10 and 0%, respectively, at a distance of 4 m. The enlargement of the area occupied by an infection center, based on the presence of sporophores, averages 12% per year in 30 to 50 year old spruce plantations. However, infection centers are usually limited for unknown reasons. Most centers larger than about five trees may be the result of coalescing centers.

Management of stands to reduce the impact of tomentosus root disease begins with a reliable detection survey. Due to the insidious nature of this root rot, surveys must include some means of sampling cross-sections of roots to detect infected wood in the center of the roots. Sampling should not be confined to the verification of the causal agent in dead or dying trees, but it should include apparently healthy trees.

Stand treatment to control this root rot is in its infancy, and treatment must be tailored to individual stands. There are several general strategies that can be applied, including species rotation, reducing inoculum, and encouraging trees that have escaped infection.

Species rotation involves replacing a susceptible species with a less susceptible or immune species. In British Columbia, more work needs to be done to determine the host-pathogen relationships of tomentosus root disease. Severely infested sites could be sanitized by growing an immune species (such as birch) on the site until the inoculum is no longer viable. Although the full extent of the susceptibility of conifer species in field conditions is unknown, some species appear to reduce the rate of spread; for instance, adding true fir species or hardwoods to spruce stands seems to slow the spread of this disease. In stands where both highly susceptible and less susceptible species are already interspersed, the most susceptible species can be removed by pre-commercial or commercial thinning to encourage the development of the less susceptible species.

Inoculum reduction by removal of the stump and most of the root system, either through push-falling or stump extraction after conventional harvesting, has proven successful in the control of several other root rots. This is a reliable means of reducing losses to root diseases and it allows for early regeneration of susceptible species; small pieces of inoculum which remain after removal of stumps have rarely proven to be a long-term threat. However, due to the extent of decay with *I. tomentosus*, breakage of the major roots at the stump may be a problem and extraction of the severely decayed roots may be difficult. Trials have been established in British Columbia to determine the effectivness of push-falling and stumping treatments in controlling tomentosus root disease.

Some trees may escape contact with inoculum if they are planted at least 3 m from old stumps that have honeycombed surface decay patterns. Hopefully, the inoculum from infected stumps will no longer be viable by the time root contact is made. Unfortunately, careful selection of planting sites, particularly where there are many disease centers, may not be practical in operational planting.

The effect of selective cutting or fertilization on development of tomentosus root disease is not known.

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September 1994

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